

# Asymmetric craters on Vesta: Formation on sloping surfaces

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## 1. Introduction

Usually the formation of craters is circular and almost symmetric. However, many observations show an asymmetric crater formation, like on Moon [1], Lutetia [2] and Vesta [3]. How these craters form is still unclear. Erosion, tectonics, oblique impacts or topography may play an important role in the formation of those craters. Vesta exhibits a significant number of craters impacting on sloping surfaces [3,4] with an unusual asymmetrical shape. There is no significant erosion or tectonics on Vesta, so it has to be an oblique impact and or the influence of topography. We combined numerical modeling and geological observations to constrain the origin of the asymmetric craters on Vesta in order to prove whether topography was the dominant influence.

## 2. Characteristics of the asymmetric craters

Asymmetric craters were formed on slopes and show a complex and diverse morphology. The craters do not show the classic circular bowl-shaped form with raised rims on the same elevation level and approximately parabolic interior profiles. The impacts show an asymmetric interior morphology and ejecta distribution. Most asymmetric craters show a well-formed semi-circular sharp rim on the uphill side and an undefined smooth rim on the downhill side. The ejecta on the downhill side are distributed on and beyond the crater rim. Ejecta on the uphill rims are only sporadically detected in thin layers. DTMs and profiles of the craters normally reveal a steep slope uphill and a shallower one downhill [4]. Other craters show a wider crater floor, which passes into the downhill slope with a reduced crater rim [4] (Figure 1).

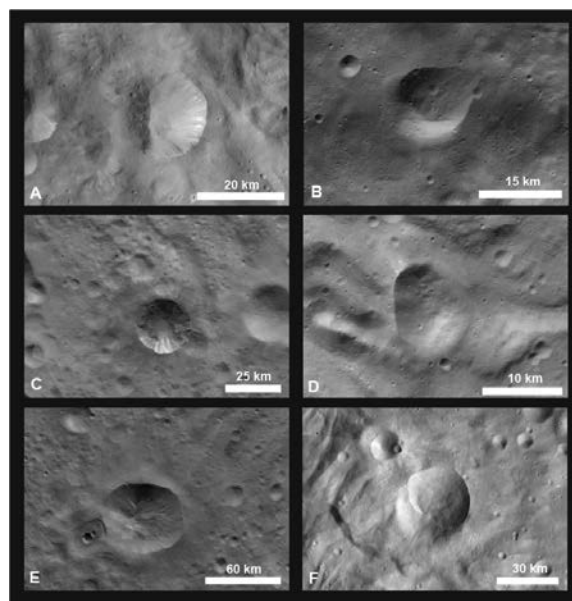


Figure 1: Different types of asymmetric craters on Vesta: (A) Type A: Typical asymmetric crater form on Vesta with a smooth downhill rim and a sharp uphill rim (Helena crater at lat 41.4°S, long 122.5°E); (B) Type B: Oblique elongated craters. LAMMO FC image of an unnamed crater at ~lat 6°S, long 299°E. (C) Type C: Rubria (lat 7.4°S, long 18.4°E); (D) Type D: V- shaped crater Oppia (lat 8°S, long 309°E); (E) Type E: Lateral elongated unnamed crater of Type E (~ lat 50°S, long 266°E); (F) LAMMO FC image of Eusebia crater (lat 42.2°S, long 204.5°E).

### 3. Results

Type A, B, and E of the observed craters show similarities in morphology, a sharp crater rim uphill and a smooth one downhill as well as ejecta on the downhill rim and only thin ejecta over the uphill rim. Type C and D show more than one part of the crater rim smoothened and a surrounding ejecta.

We performed crater size-frequency measurements to compare surrounding surfaces, ejecta deposits and crater interiors. Resulting ages of the crater interiors and the ejecta are comparable indicating the deposits to be formed directly by the impact and not influenced by subsequent mass wasting processes [3]. Three-dimensional numerical simulations have been performed to study the formation process of the unusual craters [4,5]. The results showed that

- The slope prevents the deposition of ejected material in uphill direction and results in a larger accumulation of ejecta within the crater and beyond the downhill crater rim [4,5].

Downhill-directed crater collapse results in slumping of uphill-material and produces the sharp uphill rim [4,5]. Thus, mass accumulation downhill is a mixture of ejected material and material of the initial slope [3].

### 4. Conclusions

- We found asymmetric crater on Vesta and classified them.
- Systematic analyses propose that the topography cause the formation thus all craters are formed on slopes.

### 5. Further studies

- We trying to conduct modeling of Helena and other craters/crater types to obtain constraints for their formation
- more intense and “quantitative” modeling of impacts in topography
- We have to perform more detailed investigations of crater slope angles and surface slope angles.

### References

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